Applied Neuroscience at the AFRL 711th Human Performance Wing

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 2010	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Applied Neuroscience at the AFRL 711thHuman Performance Wing	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Adaptive Interfaces 711th Human Performance Wing Air Force Research Laboratory**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA560467. Indo-US Science and Technology Round Table Meeting (4th Annual) - Power Energy and Cognitive Science Held in Bangalore, India on September 21-23, 2010. U.S. Government or Federal Purpose Rights License

14. ABSTRACT

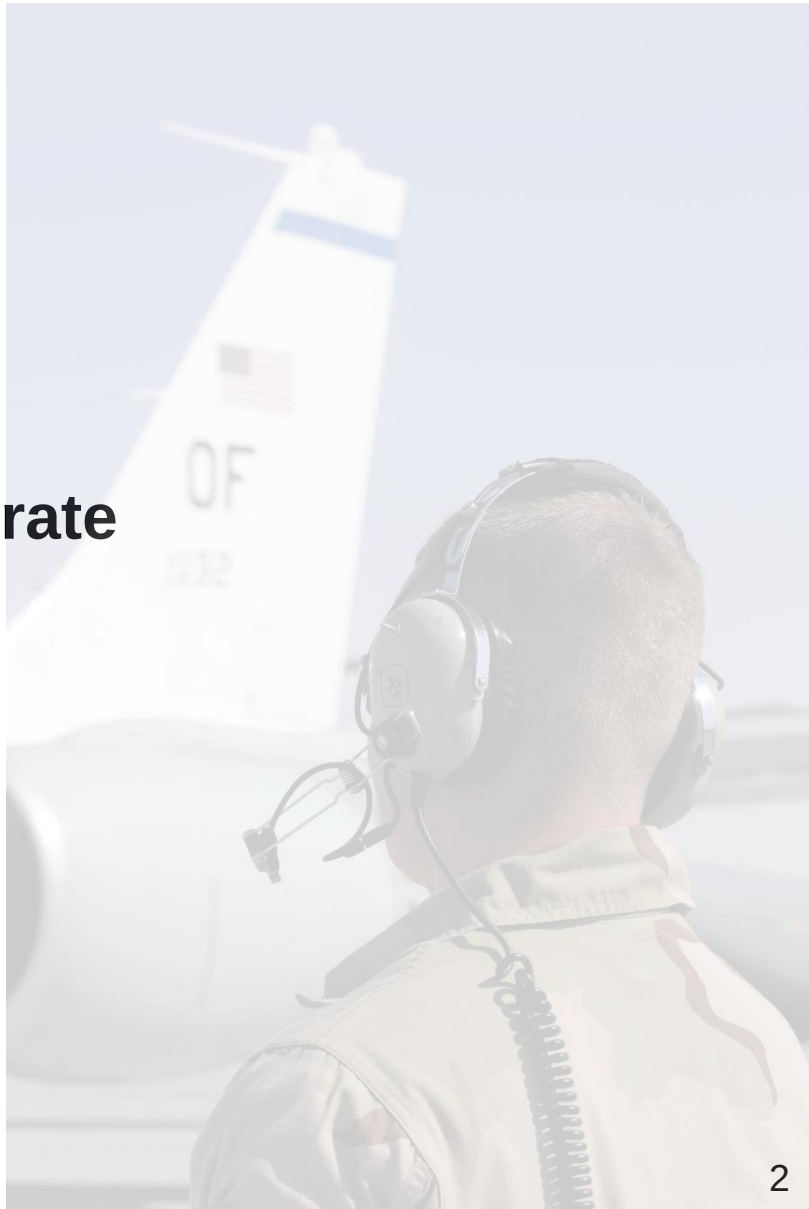
One of the fundamental challenges facing designers of military aviation systems has always been how to integrate humans and machines into an effective system. The Air Force Research Laboratory's Decision Making Core Technology Competency (CTC) wrestles with one of the most challenging aspects of creating such integrated systems, namely the design of the interface between the human airman and the sophisticated and increasingly intelligent machinery with which he or she must coalesce in order to perform the mission. Historically, optimizing the human-machine interface required little more than increasing the compatibility of the machine's displays with the human sensory system and the machine's controls to human motor capabilities. But in environments in which the humans must function with machines processing greater and greater intelligent automation, working with larger and larger data bases of situational knowledge, and teaming with larger and more distributed teams of other airmen and non-human systems, the focus of human machine interface research must shift from relatively peripheral perceptual-motor issues to optimizing the interface between the airman's highest cognitive capabilities and the networked knowledge and intelligence provided with modern networked systems. To accomplish this, the traditional research to optimize the use human sensory systems as conduits of information and knowledge must be bolstered by research integrating humans with intelligent automation and exploiting understanding of higher cognition that can be provided my modern neuroscience. Executing this combination of essential human-machine interface research is the mission of the Decision Making CTC. The Applied Neuroscience component of the CTC is challenged to develop innovative neuroergonomic methodologies and integrated approaches to assess and classify individual and team operator functional state and provide adaptive mitigations to aid decision making effectiveness. Recent capability gains in the neuroergonomics field will be exploited to improve and sustain effective performance levels in small team environments. Current and planned research in this area will be discussed.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**34**	

711th Human Performance Wing
Overview

- **Vision and Mission**
- **Organization**
- **Mission Units**
  - **Human Effectiveness Directorate**
- **Applied Neuroscience**



711th Human Performance Wing
Vision and Mission

– The Human Performance Wing –
Supporting the Most Critical Air Force Resource

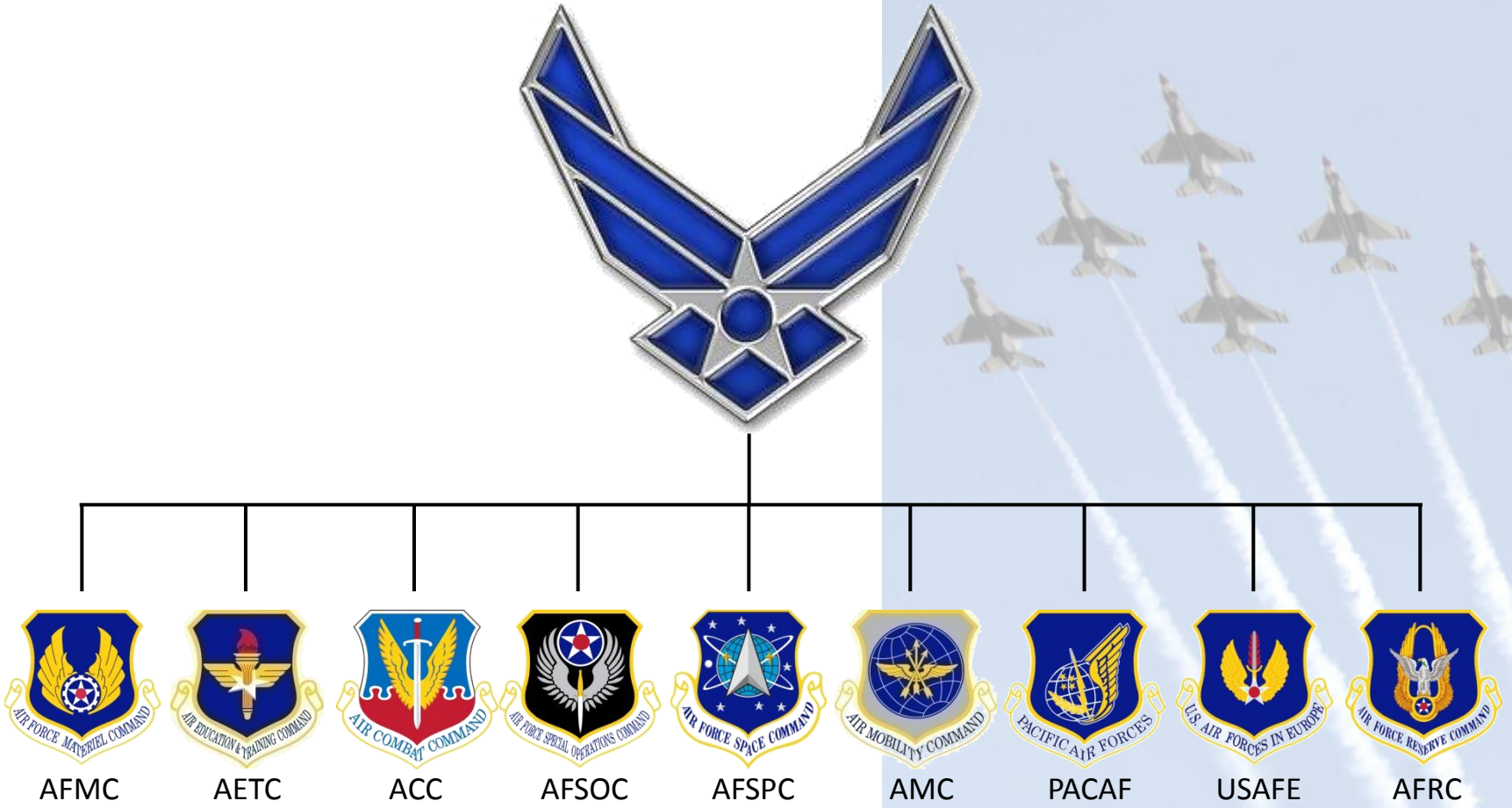
Vision

World Leader for Human Performance

Mission

Advance Human Performance in Air, Space, and Cyberspace through Research, Education, and Consultation.

USAF Major Commands



USAF Major Commands

AFMC AETC ACC AFSOC AFSPC AMC PACAF USAFE AFRC

Air Force Materiel Command

Air Logistics Centers

AFRL

AAC

ESC

ASC

AFFTC

Air Force Materiel Command

Air Logistics Centers

AFRL

AAC

ESC

ASC

AFFTC

AFRL Organization
S&T Directorates


AFOSR


Propulsion (RZ)


Directed Energy (RD)

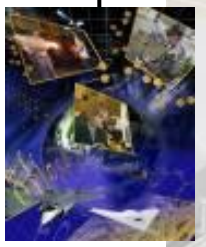

Information (RI)

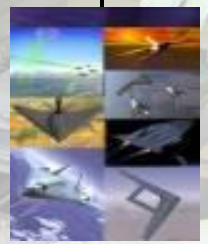
Human Performance Wing (HPW)


Munitions (RW)


Sensors (RY)


Space Vehicles (RV)


Materials & Manufacturing (RX)


Air Vehicles (RB)

Human Effectiveness Directorate (RH)

AFRL Organization
S&T Directorates

AFOSR

Propulsion
(RZ)

Directed Energy
(RD)

Information
(RI)

Human Performance
Wing (HPW)

Munitions
(RW)

Sensors
(RY)

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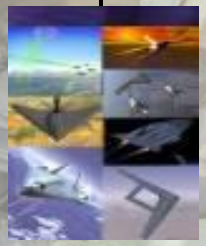
Materials &
Manufacturing (RX)



Air Vehicles
(RB)

Human Effectiveness
Directorate (RH)

711th Human Performance Wing

USAF School of Aerospace Medicine (USAFSAM)

Human Performance Integration Directorate (711 HPW/HP)

Human Effectiveness Directorate (711 HPW/RH)

Human Effectiveness Directorate

Vision

Leading the Air Force in Human-Centered Research

Mission

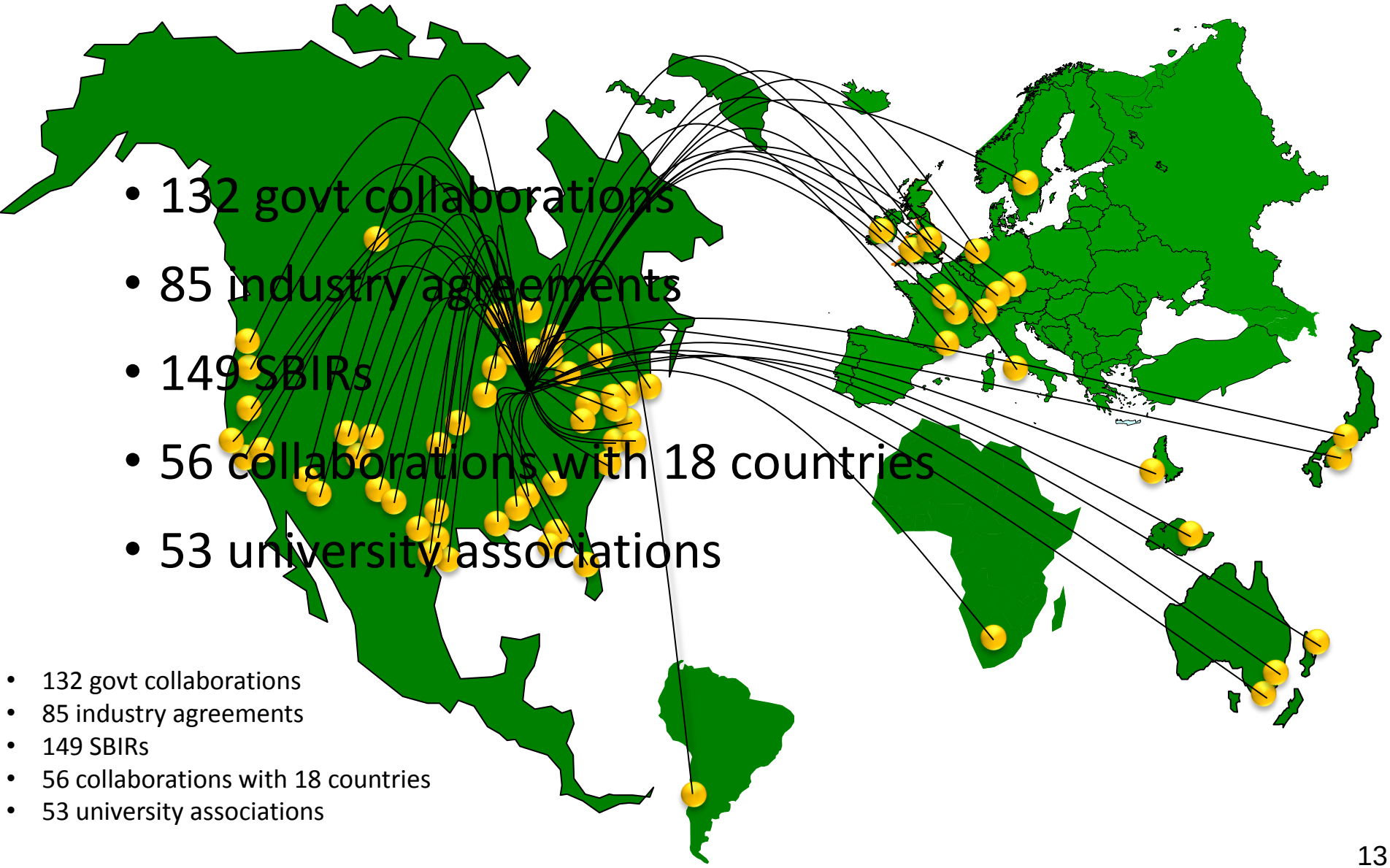
Integrate Bio… …Technologies
to Optimize … …n's Capabilities
to Fly, Fight, … …, and Cyberspace

The Breadth & Integration of 711 HPW/RH

To Societies

From Molecules

Human Effectiveness Directorate Collaborations



- 132 govt collaborations
- 85 industry agreements
- 149 SBIRs
- 56 collaborations with 18 countries
- 53 university associations

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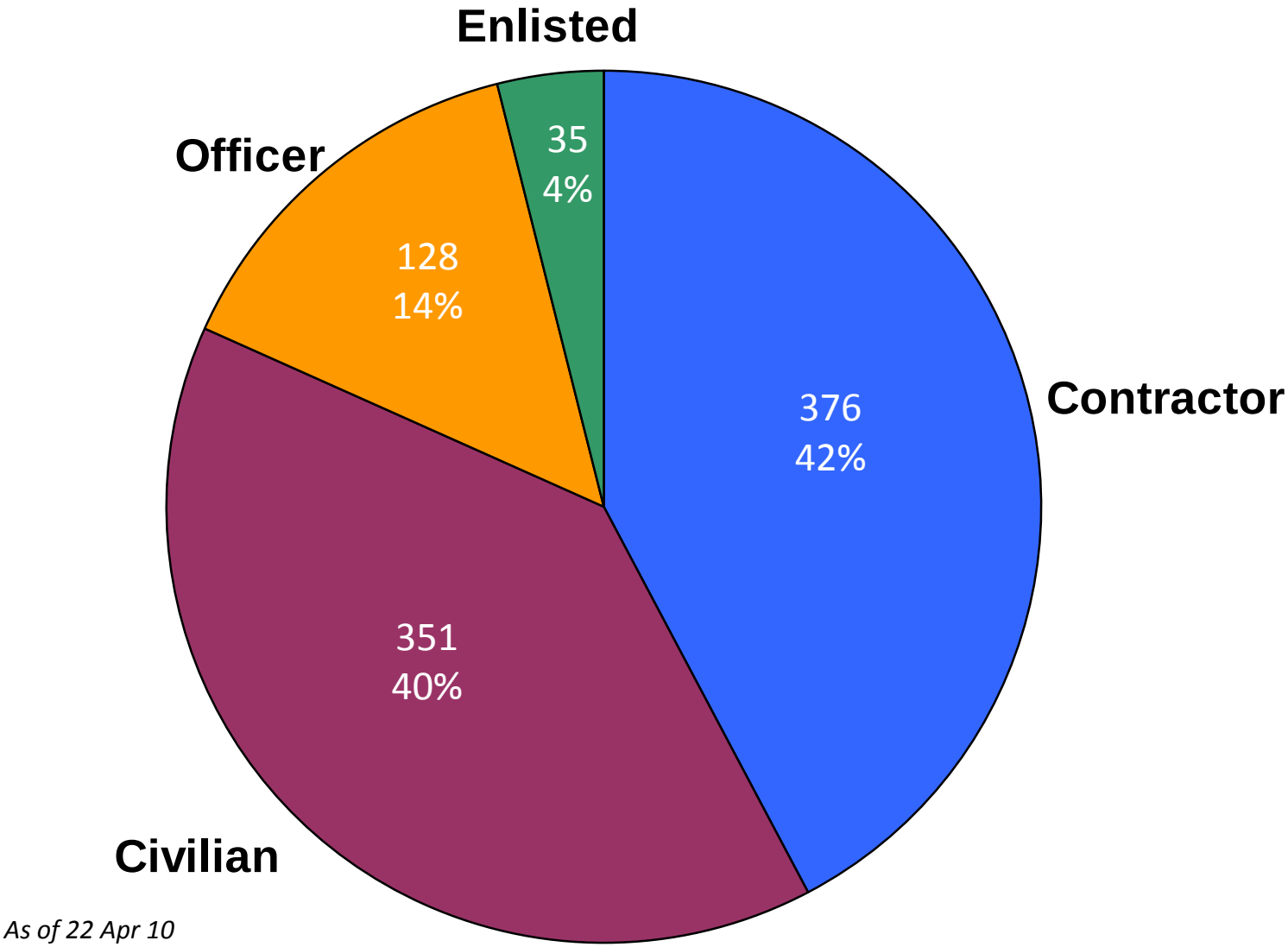
Human Effectiveness Directorate

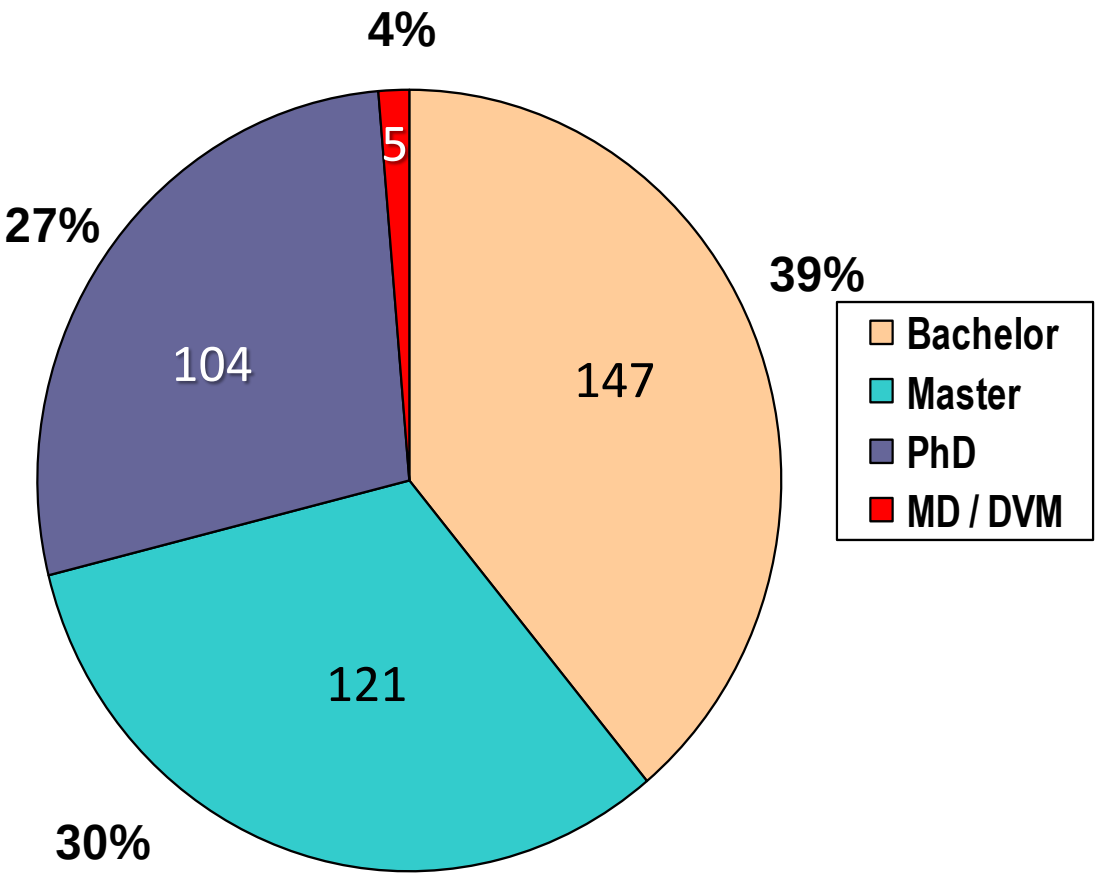
Total Workforce - 890



As of 22 Apr 10

Human Effectiveness Directorate

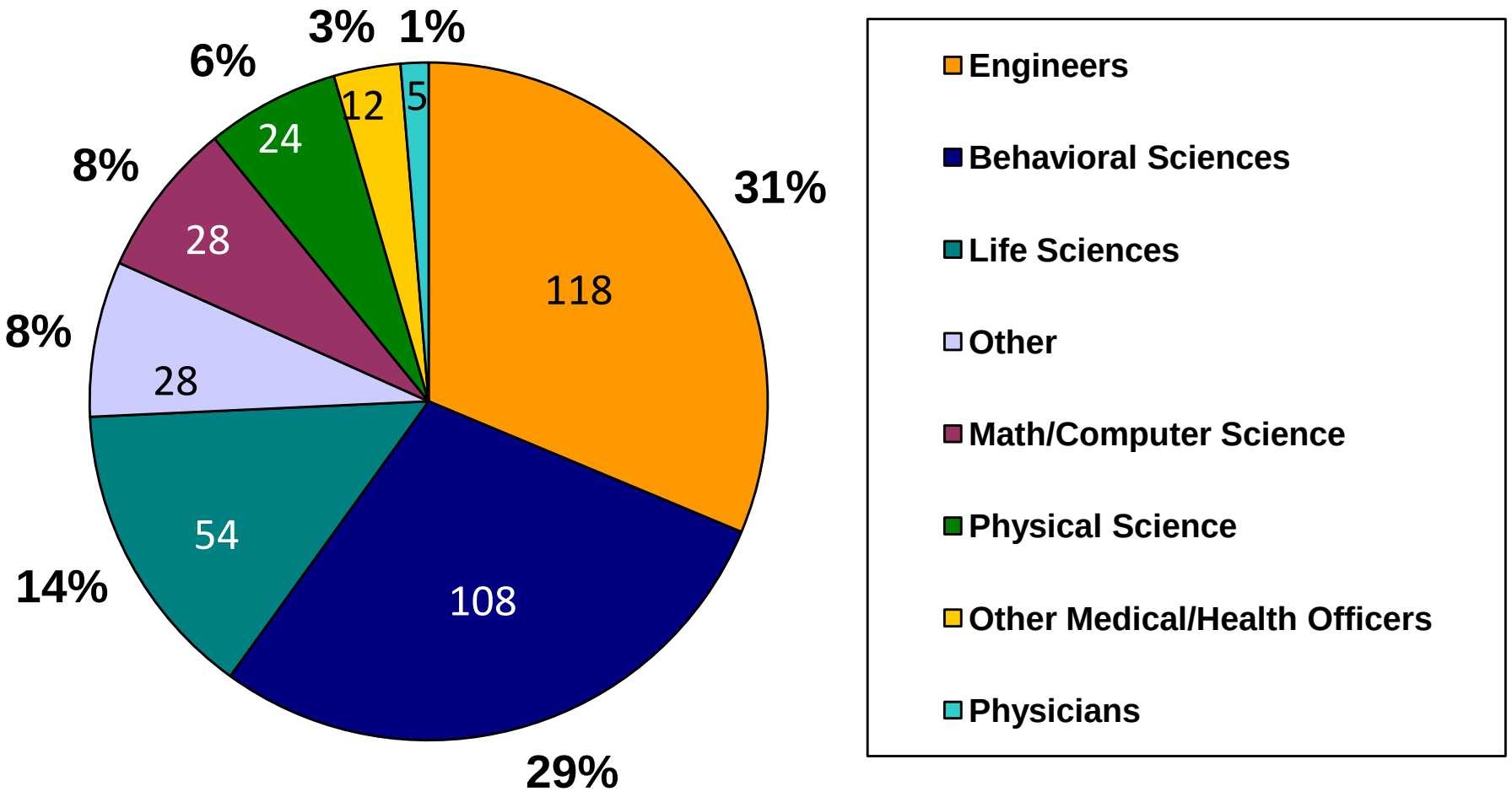
S&E Academic Levels – Govt Only



Assigned Govt S&E Workforce = 377

As of 22 Apr 10

Human Effectiveness Directorate
Science & Engineering Disciplines



Based on S&Es assigned (mil & civ) as of 13 May 2009 = 377

As of 22 Apr 10

Human Effectiveness Directorate
Core Technical Competencies (CTC)

Four Core Technology Competencies (CTCs)
with 13 Sub-CTCs

Decision Making CTC

Battlespace Acoustics

Revolutionize auditory displays to maximize operator effectiveness in complex multisource environments

Battlespace Visualizations

Discover novel information presentation techniques to improve human decision making

Human Role in Semi-autonomous Systems

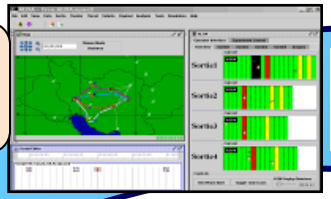
Understand and apply the fundamental underpinnings of human-automation interaction

Applied Neuroscience

An inter-disciplinary approach to examine the brain and behavior at work – from individuals to teams

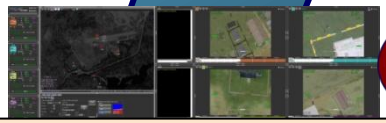
Role of Human in Autonomous Systems
Research Thrusts - Basic to Applied

Human-automation interaction
(methods, visibility, attention, allocation)

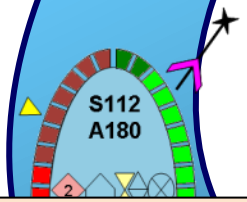


Integrated crew stations:
increased span of control

Multi-modal & 3D interfaces for
supervisory control



Interfaces tailored for future
capabilities & missions



Multi-UAV management
(glyphs, task switching, timeline)

Multi-platform control station
hardware/software framework

Sensor inspection aids

Applied Neuroscience Research

Focus the power and potential of neuroscience to improve human performance

- **Automatically assess, manage, and intuitively mitigate task overload**
- **Facilitate human/machine collaboration**

What are we trying to do?

- **Study the brain and behavior <u>at work</u>**
  - **Neuroergonomics**
- **Inter-disciplinary approach: neural, behavioral, and computational**
- **One smaller piece of the very large world of neuroscience, with a real-world task focus**
- **Behavior and performance alone are simply not enough to push the state of the art**

Why Neuroergonomics?

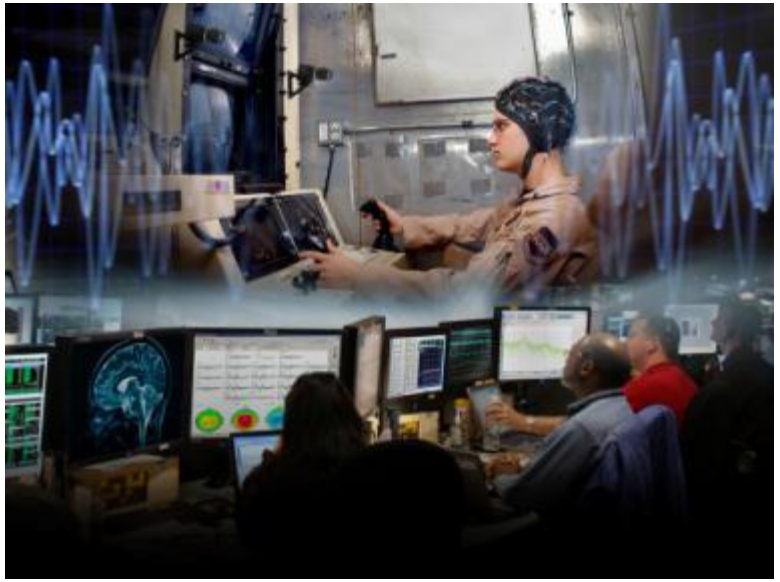
- **Huge body of neuroscientific research; vast majority is basic science and not application oriented**
- **Neuroergonomics is not an immediate concern for many neuroscientists**
- **Neuroergonomic research is application oriented, though not all is specific to Air Force interests**
- **External funding directed at integrative neuroergonomic research is limited**

Strategy

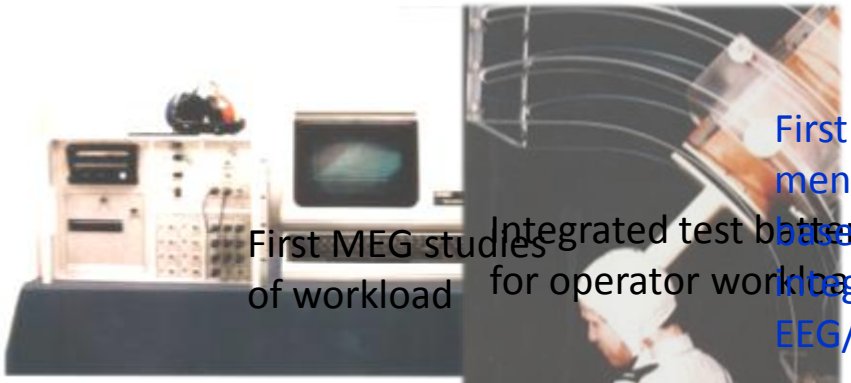
- Conduct research with more complex, realistic tasks that aid in advancing the application of neuroscience
  - Basic research with simple tasks well-covered outside AFRL; continue to monitor and leverage
- Focus on integration of methods
- Utilize external collaborations to increase depth and breadth of neuroergonomics research

Research Objectives

- **Provide a full spectrum of enhanced capabilities:**
  - **Adaptive systems that monitor operator cognitive state and self-modify in real time**
  - **Materiel solutions optimized to meet human cognitive needs via neuroscience applied to test and evaluation**
  - **Support teaming and collaboration research performed by RHCPT**



History of Applied Neuroscience Research



First MEG studies of workload

Integrated test battery for operator workload

First to classify mental workload based on integrated EEG/ECG

1980

1985

1990

1995

2000

2005

2010

First EEG studies of workload at AFRL – evoked potentials

First in-flight physiological workload recording

History of Applied Neuroscience Research

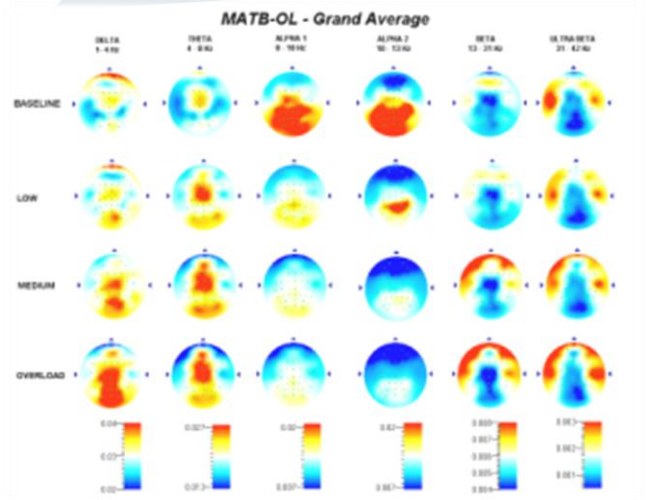
First successful real-time workload classification

Closed-loop adaptive aiding based on EEG/ECG

1980 1990 2000 2010

1995

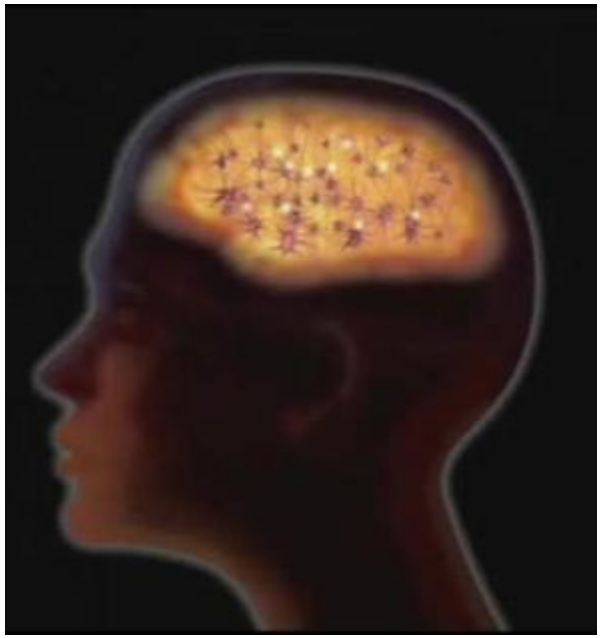
2005



Measured EEG workload in complex tasks

Current Applied Neuroscience Research

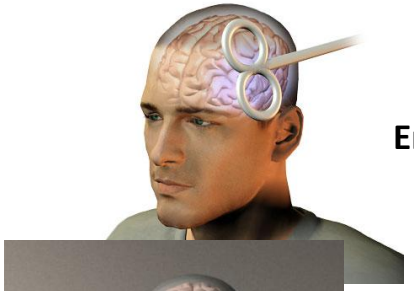
- **Mix of in-house and external collaborations**
  - **Collaboration with ARL, NRL, IARPA, and numerous universities and businesses**
- **In-house research takes full advantage of the many programs that provide student employees and interns**

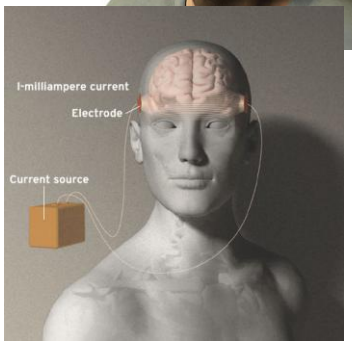


- **Current projects include**
  - **testing new sensors**
  - **evaluating applicability of academic paradigms**
  - **integrative research**
  - **extension to novel domains, such as teamwork and collaborative tools**
  - **Sensors/Mitigations**

Diverse Programs in Cognitive Performance Optimization

Molecular Mechanisms of Human Learning and Memory

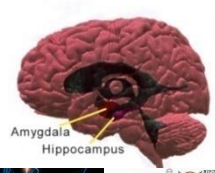


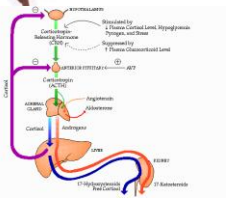


Non-Invasive Brain Stimulation to directly augment cognition and improve performance or accelerate learning

Enrichment strategies improve brain structure and response to stress

Agility-Based Physical Training Promotes Cognitive Performance



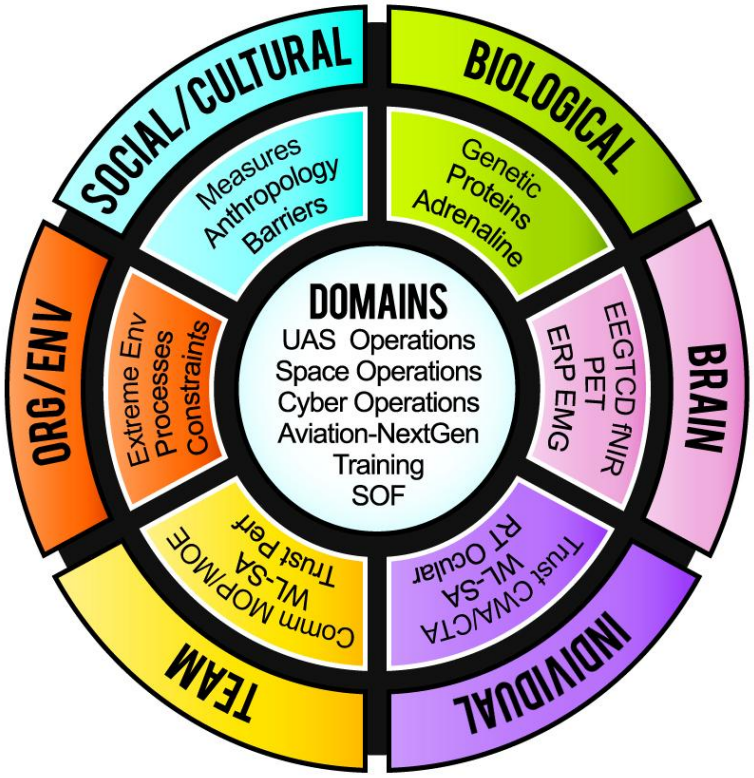


Markers of stress, inflammation and plasticity correspond with performance effects

HUMAN Approach

360° ANALYSIS

MODEL GENERATION & TESTING



COVERGENCE

INTELLECTUAL CAPITAL

Objectives

Where we are today

Objectives

Where we plan to be in 4 years

Human
Universal
Measurement and
Assessment
Network

Potential Future Work

- **Selection**
- **Adaptive Training**
- **Trust (interpersonal and human/machine)**
- **Cognitive Neurofeedback**

Human Effectiveness Directorate
Summary

- **Dedicated to supporting Air Force people and improving their performance**
- **Focused on our science and technology programs that address user capability needs**
- **Working closely with the technology users to meet their requirements**

"Unleashing the power of human performance through technology"

Questions?


711TH HUMAN PERFORMANCE WING


Human Effectiveness
DIRECTORATE


UNITED STATES AIR FORCE
SCHOOL OF AEROSPACE MEDICINE
Volanti Subrecumbo


Human Performance Integration
Manpower
Environment
Personnel
Training
Human Factors Engineering
Safety
Occupational Health
Habitability
Survivability